production of immunity or in healing the disease is the time which elapses between the infection and the protective inoculation, that the action of the latter is the more rapid and the more successful the sooner it follows upon the former, it is at once apparent where, at any rate, some of the difficulties lie in its successful application to human beings. Whereas the exact moment is known when the experimental infection in the animal takes place, in the human subject days or weeks may pass between the infection and the declaration of the disease.

THE CENTENARY OF GILBERT WHITE.

THE wonted tranquillity of the little Hampshire village of Selborne was disturbed on Saturday by the invasion of a band of pilgrims who came to look upon the shrine of Gilbert White, and by the sight obtained a renewed love of nature. Drawn by a feeling of regard, members of the Selborne Society, and other disciples of White, congregated from all parts of the country, and paid homage to their master. Never within the memory of the oldest inhabitant had so many people been gathered together at Selborne, and we doubt not that the villagers failed to realise what attraction there could be in a man whose characteristics, according to an old woman who remembered him, were that "he would walk about the lanes tap-tapping at the trees, and stooping every now and then to wipe the dust off his shoes." But one thing marred the enjoyment of Saturday's meeting. A band of gipsies, with a terrible barrel-organ, and all the paraphernalia of a country fair, had installed themselves not a stone's-throw from the house in which Gilbert White lived his peaceful life. And, worst of all, they possessed a steam-syren, the shriek and screech of which penetrated everywhere, even to the high Hangers, in which the Selborne naturalist supposed that swallows hibernated.

The Earl of Selborne presided at luncheon, and, in proposing "The Memory of Gilbert White," dwelt upon the sterling qualities of the man, and the remarkable character of his books dealing with the natural history and antiquities of Selborne. White's life was devoted to observing and recording natural productions and phenomena. He was gifted with shrewdness of discernment, and that one essential qualification of a true man of science—the power of faithfully chronicling all and every observation. It was thought by some that the naturalist whose centenary they were commemorating had nothing else to do but wander about, and observe the habits of birds, beasts, fishes, and insects; but that was a great mistake. He had to perform "the daily round, the common task" that falls to the lot of all, and diligently did he fulfil his duties.

Mr. Darwin proposed "Prosperity to the Selborne Society and its branches." In responding, Mr. Otter, one of the founders of the society, dwelt upon the fact that their object was to inculcate and foster a love of nature, and to wage war in defence of her beauties. To them the ruthless field-naturalist and the sporting collector of specimens were enemies.

Mr. Wakefield followed with a description of the good work done by the Thames Valley branch in preserving "beauty-spots" from jerry-builders and their kindred.

The Earl of Stamford, in proposing "Prosperity to the Hampshire Field Club," the members of which joined the London party at Selborne, remarked that be had found reason to believe that one of the figures shown in the quarto edition of White's book is a likeness of the author himself, hence it could no longer be said that no portrait of him was in existence. Mr. R. H. White, however, was of the opinion that the evidence was not of a positive character.

The question of a memorial to White was touched by the Earl of Selborne, but he thought that the best plan would be to "Look not on the picture, but the book," and leave that to be handed down to the end of time, for nothing more was needed to perpetuate the memory of the man. With this sentiment we by no means agree. A monument is not erected merely to prevent a man's name and deeds from sinking to oblivion. It should show to the people that he was one whom men delight to honour. We are apt to be far too prosaic in these matters, and to consider the raising of images and other memorials as more or less unnecessary conventionalities. This conviction has grown upon us because we have seen statues erected to comparatively obscure individuals time without number, while the works of men of science are unrecognised. It does not say much for the naturalists of this country if the centenary of Gilbert White is allowed to pass without some tangible illustration being given of their regard for the father of them all.

INTERFERENCE BANDS AND THEIR APPLICATIONS.[1]

THE formation of the interference bands, known as Newton's rings, when two slightly curved glass plates are pressed into contact, was illustrated by an acoustical analogue. A high-pressure flame B (Fig. 1) is sensitive to sounds which reach it in the direction EB, but is insensitive to similar sounds which reach it in the nearly perpendicular direction AB. A is a "bird-call," giving a pure sound (inaudible) of wave-length (λ) equal to about 1 cm.; C and D are reflectors of perforated zinc. If C acts alone, the flame is visibly excited by the waves reflected from it, though by far the greater part of the energy is transmitted. If D, held parallel to C, be then brought into action, the result depends upon the interval between the two partial reflectors. The reflected sounds may co-operate, in which case the flame flares vigorously; or they may interfere, so that the flame recovers, and behaves as if no sonnd at all were falling upon it. The first effect occurs when the reflectors are close together, or are separated by any multiple of $\frac{1}{2}\sqrt{2}.\lambda$; the second when the interval is midway between those of the above-mentioned series, that is, when it coincides with an odd multiple of $\frac{1}{4}\sqrt{2}.\lambda$. The factor $\sqrt{2}$ depends upon the obliquity of the reflection.

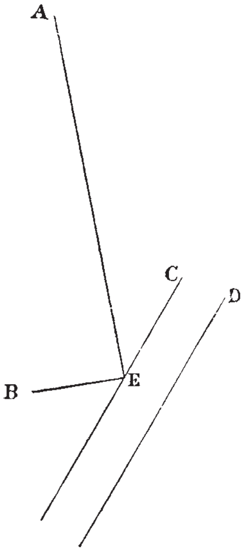

FIG. 1.

The coloured rings, as usually formed between glass plates, lose a good deal of their richness by contamination with white light reflected from the exterior surfaces. The reflection from the hindermost surface is easily got rid of by employing an opaque glass, but the reflection from the first surface is less easy to deal with. One plan, used in the lecture, depends upon the use of slightly wedge-shaped glasses (2°) so combined that the exterior surfaces are parallel to one another, but inclined to the interior operative surfaces. In this arrangement the false light is thrown somewhat to one side, and can be stopped by a screen suitably held at the place where the image of the electric arc is formed.

The formation of colour and the ultimate disappearance of the bands as the interval between the surfaces increases, depends upon the mixed character of white light. For each colour the bands are upon a scale proportional to the wave-length for that colour. If we wish to observe the bands when the interval is considerable—bands of high interference as they are called—the most natural course is to employ approximately homogeneous light, such as that afforded by a soda flame. Unfortunately, this light is hardly bright enough for projection upon a large scale.

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[1] Abstract of a lecture delivered at the Royal Institution, on Friday, March 24, 1893, by Lord Rayleigh.

A partial escape from this difficulty is afforded by Newton's observations as to what occurs when a ring system is regarded through a prism. In this case the bands upon one side may become approximately achromatic, and are thus visible to a tolerably high order, in spite of the whiteness of the light. Under these circumstances there is, of course, no difficulty in obtaining sufficient illumination; and bands formed in this way were projected upon the screen.[1]

The bands seen when light from a soda flame falls upon nearly parallel surfaces have often been employed as a test of flatness. Two flat surfaces can be made to fit, and then the bands are few and broad, if not entirely absent; and, however the surfaces may be presented to one another, the bands should be straight, parallel, and equi-distant. If this condition be violated, one or other of the surfaces deviates from flatness. In Fig. 2, A and B represent the glasses to be tested, and C is a lens of two or three feet focal length. Rays diverging from a soda flame at E are rendered parallel by the lens, and after reflection from the surfaces are re-combined by the lens at E. To make an observation, the coincidence of the radiant point and its image must be somewhat disturbed, the one being displaced to a position a little beyond, and the other to a position a little in front of, the diagram.

The eye, protected from the flame by a suitable screen, is placed at the image, and being focused upon AB, sees the field traversed by bands. The reflector D is introduced as a matter of convenience to make the line of vision horizontal.

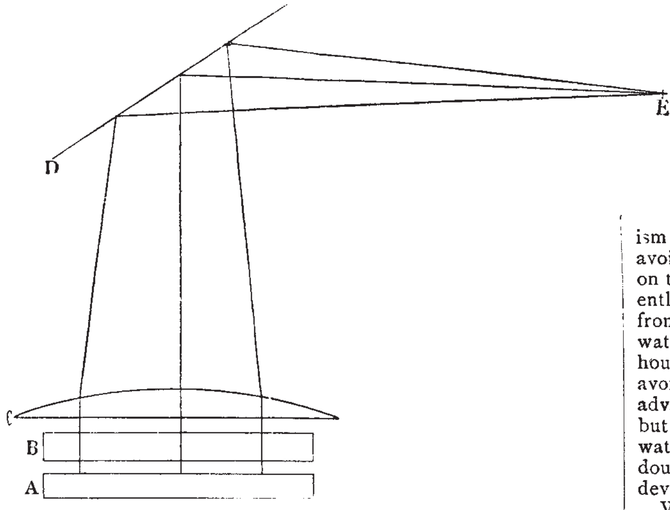

Fig. 2.

These bands may be photographed. The lens of the camera takes the place of the eye, and should be as close to the flame as possible. With suitable plates, sensitised by cyanin, the exposure required may vary from ten minutes to an hour. To get the best results, the hinder surface of A should be blackened, and the front surface of B should be thrown out of action by the superposition of a wedge-shaped plate of glass, the intervening space being filled with oil of turpentine or other fluid having nearly the same refraction as glass. Moreover, the light should be purified from blue rays by a trough containing solution of bichromate of potash. With these precautions the dark parts of the bands are very black, and the exposure may be prolonged much beyond what would otherwise be admissible.

The lantern slides exhibited showed the elliptical rings indicative of a curvature of the same sign in both directions, the hyperbolic bands corresponding to a saddle-shaped surface, and the approximately parallel system due to the juxtaposition of two telescopic "flats," kindly lent by Mr. Common. On other plates were seen grooves due to rubbing with rouge along defined track, and depressions, some of considerable regularity, obtained by the action of diluted hydrofluoric acid, which was allowed to stand for some minutes as a drop upon the surface of the glass.

By this method it is easy to compare one flat with another, and thus, if the first be known to be free from error, to determine the errors of the second. But how are we to obtain and verify a standard? The plan usually followed is to bring *three* surfaces into comparison. The fact that two surfaces can be made to fit another in all azimuths proves that they are spherical and of equal curvatures, but one convex and the other concave, the case of perfect flatness not being excluded. If A and B fit another, and also A and C, it follows that B and C must be similar. Hence, if B and C also fit one another, all three surfaces must be flat. By an extension of this process the errors of three surfaces which are not flat can be found from a consideration of the interference bands which they present when combined in three pairs.

But although the method just referred to is theoretically complete, its application in practice is extremely tedious, especially when the surfaces are not of revolution. A very simple solution of the difficulty has been found in the use of a free surface of water, which, when protected from tremors and motes, is as flat as can be desired.[1] In order to avoid all trace of capillary curvature it is desirable to allow a margin of about 1½ inch. The surface to be tested is supported horizontally at a short distance ($\frac{1}{10}$ or $\frac{1}{20}$ inch) below that of the water, and the whole is carried upon a large and massive levelling stand. By the aid of screws the glass surface is brought into approximate parallelism with the water. In practice the principal trouble is in the avoidance of tremors and motes. When the apparatus is set up on the floor of a cellar in the country, the tremors are sufficiently excluded, but care must be taken to protect the surface from the slightest draught. To this end the space over the water must be enclosed almost air-tight. In towns, during the hours of traffic, it would probably require great precaution to avoid the disturbing effects of tremors. In this respect it is advantageous to diminish the thickness of the layer of water; but if the thinning be carried too far, the subsidence of the water surface to equilibrium becomes surprisingly slow, and a doubt may be felt whether after all there may not remain some deviation from flatness due to irregularities of temperature.

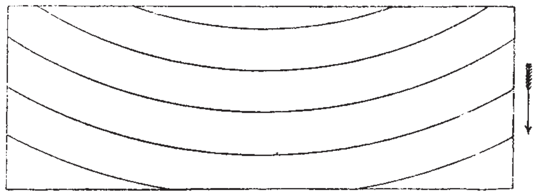

Fig. 3.

With the aid of the levelling screws the bands may be made as broad as the nature of the surface admits; but it is usually better so to adjust the level that the field is traversed by five or six approximately parallel bands. Fig. 3 represents bands actually observed from the face of a prism. That these are not straight, parallel, and equi-distant is a proof that the surface deviates from flatness. The question next arising is to determine the direction of the deviation. This may be effected by observing the displacement of the bands due to a known motion of the levelling screws; but a simpler process is open to us. It is evident that if the surface under test were to be moved downwards parallel to itself, so as to increase the thickness of the layer of water, every band would move in a certain direction, viz. *towards* the side where the layer is thinnest. What amounts to the same, the retardation may be increased, without touching the apparatus, by so moving the eye as to *diminish* the obliquity of the reflection. Suppose, for example, in Fig. 3 that the movement in question causes the bands to travel downwards, as indicated by the arrow. The inference is that the surface is concave. More glass must be removed at the ends of the bands than in the middle in order to straighten them. If the object be to correct the errors by local polishing operations upon the surface, the rule is that *the bands, or any parts of them, may be rubbed in the direction of the arrow.*

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[1] The theory is given in a paper upon "Achromatic Interference Bands," *Phil. Mag.*, August 1889.

[1] The diameter would need to be 4 feet in order that the depression at the circumference, due to the general curvature of the earth, should amount to $\frac{1}{20}\lambda$.

A good many surfaces have thus been operated upon; and although a fair amount of success has been attained, further experiment is required in order to determine the best procedure. There is a tendency to leave the marginal parts behind; so that the bands, though straight over the greater part of their length, remain curved at their extremities. In some cases hydrofluoric acid has been resorted to, but it appears to be rather difficult to control.

The delicacy of the test is sufficient for every optical purpose. A deviation from straightness amounting to $\frac{1}{10}$ of a band interval could hardly escape the eye, even on simple inspection. This corresponds to a departure from flatness of $\frac{1}{20}$ of a wave-length in water, or about $\frac{1}{30}$ of the wave-length in air. Probably a deviation of $\frac{1}{100}$ λ could be made apparent.

For practical purposes a layer of moderate thickness, adjusted so that the two systems of bands corresponding to the duplicity of the soda line do not interfere, is the most suitable. But if we wish to observe bands of high interference, not only must the thickness be increased, but certain precautions become necessary. For instance, the influence of obliquity must be considered. If this element were absolutely constant, it would entail no ill effect. But in consequence of the finite diameter of the pupil of the eye, various obliquities are mixed up together, even if attention be confined to one part of the field. When the thickness of the layer is increased, it becomes necessary to reduce the obliquity to a minimum, and further to diminish the aperture of the eye by the interposition of a suitable slit. The effect of obliquity is shown by the formula

$$2t(1 - \cos\theta) = n\lambda.$$

The necessary parallelism of the operative surfaces may be obtained, as in the above-described apparatus, by the aid of levelling. But a much simpler device may be employed, by which the experimental difficulties are greatly reduced. If we superpose a layer of water upon a surface of mercury, the flatness and parallelism of the surfaces take care of themselves. The objection that the two surfaces would reflect very unequally may be obviated by the addition of so much dissolved colouring matter, *e.g.* soluble aniline blue, to the water as shall equalise the intensities of the two reflected lights. If the adjustments are properly made, the whole field, with the exception of a margin near the sides of the containing vessel, may be brought to one degree of brightness, being, in fact, all included within a fraction of a band. The width of the margin, within which rings appear, is about one inch, in agreement with calculation founded upon the known values of the capillary constants. During the establishment of equilibrium after a disturbance, bands are seen due to variable thickness, and when the layer is thin, persist for a considerable time.

When the thickness of the layer is increased beyond a certain point, the difficulty above discussed, depending upon obliquity, becomes excessive, and it is advisable to change the manner of observation to that adopted by Michelson. In this case the eye is focused, not, as before, upon the operative surfaces, but upon the flame, or rather upon its image at E (Fig. 2). For this purpose it is only necessary to introduce an eye-piece of low power, which with the lens C (in its second operation) may be regarded as a telescope. The bands now seen depend entirely upon obliquity according to the formula above written, and therefore take the form of circular arcs. Since the thickness of the layer is absolutely constant, there is nothing to interfere with the perfection of the bands except want of homogeneity in the light.

But, as Fizeau found many years ago, the latter difficulty soon becomes serious. At a very moderate thickness it becomes necessary to reduce the supply of soda, and even with a very feeble flame a limit is soon reached. When the thickness was pushed as far as possible, the retardation, calculated from the volume of liquid and the diameter of the vessel, was found to be 50,000 wave lengths, almost exactly the limit fixed by Fizeau.

To carry the experiment further requires still more homogeneous sources of light. It is well known that Michelson has recently observed interference with retardations previously unheard of, and with the aid of an instrument of ingenious construction has obtained most interesting information with respect to the structure of various spectral lines.

A curious observation respecting the action of hydrofluoric acid upon polished glass surfaces was mentioned in conclusion. After the operation of the acid the surfaces appear to be covered with fine scratches, in a manner which at first suggested the idea that the glass had been left in a specially tender condition, and had become scratched during the subsequent wiping. But it soon appeared that the effect was a *development* of scratches previously existent in a latent state. Thus parallel lines ruled with a knife edge, at first invisible even in a favourable light, became conspicuous after treatment with acid. Perhaps the simplest way of regarding the matter is to consider the case of a furrow with perpendicular sides and a flat bottom. If the acid may be supposed to eat in equally in all directions, the effect will be to *broaden* the furrow, while the depth remains unaltered. It is possible that this method might be employed with advantage to *intensify* (if a photographic term may be permitted) gratings ruled upon glass for the formation of spectra.

FROST FREAKS.

MR. LESTER F. WARD describes some remarkable frost figures in the current number of *The Botanical Gazette*. He says that on a bright frosty morning in December, 1892, Mr. Victor Mason and himself observed some white objects looking like icicles close to the ground, along the border of a pine wood. A closer examination showed that they were in truth nothing but ice, but that instead of icicles they were veritable freaks of frost. Every one was firmly attached to the stem of a small herbaceous plant which had succumbed to the season but still stood erect. The attachment was always close to the base, often at the very ground, sometimes an inch above. At a distance, the frost-works had the appearance of cylindrical masses, but one need not come very near to see that such was not the case. In fact, they really consisted of several thin foils or wings from one to three inches in width, firmly attached by one edge to the stem of the plant, thus standing in a vertical position. From this attachment each of these little ice sheets projected out horizontally or with a slight upward tendency, not straight and stiff, but gently and gracefully curving or coiling into a beautiful conch-like roll at the distal margin. There were always several of these, usually three, four, or five, all attached to the same vertical portion of the stem but at regular intervals around it like the paddles of a flutter-wheel, but all curving in the same direction after the manner of a turbine-wheel. Thus, where there were four they stood with each pair opposite, as in the figure, which represents a side view. The amount of curving varied considerably, and the coil filled up most of the interval between the plates giving the object a compact appearance. The ice was white, opaque, and singularly light, as if consisting of congealed froth, but in all cases the scrolls bore horizontal stripes like those of a flag, resulting from degrees in the whiteness, varying from alabaster to nearly transparent. These stripes added greatly to the beauty of these singular objects. In some cases the inner margin, instead of being straight, was sinuous,